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(54) **SPLIT BLADE RETENTION RACE WITH INNER AND OUTER CHAMFERS**

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B64C 11/04 (2006.01)

(52) **U.S. Cl.**
CPC ***B64C 11/04*** (2013.01)

(58) **Field of Classification Search**
CPC B64C 11/04; B64C 11/06; F16C 19/06; F16C 19/163; F16C 33/583; F16C 33/585; F16C 33/60; F16C 2326/43
USPC .... 416/205, 214 A, 214 R, 129; 384/499, 384/501, 505, 506, 570
See application file for complete search history.

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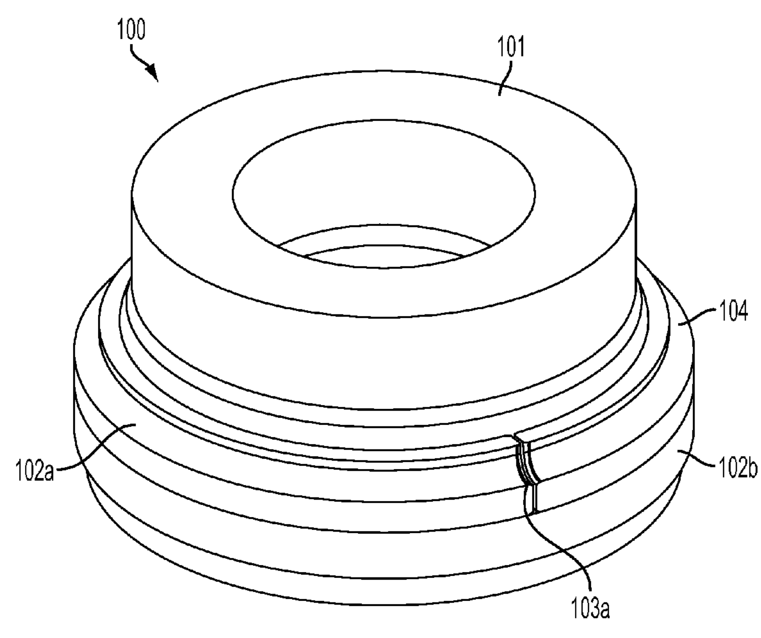
(57) **ABSTRACT**

A blade shank assembly for an aircraft propeller blade includes a blade shank; and a split blade retention race encircling the blade shank, the split blade retention race comprising two sections separated by two splits, the two splits being perpendicular to a race surface of the split blade retention race, wherein the split blade retention race comprises: an inner chamfer located between a surface of the split blade retention race that is adjacent to the blade shank and a split surface of the split blade retention race at each of the two splits; and an outer chamfer located between the race surface of the split blade retention race and the split surface at each of the two splits.

20 Claims, 6 Drawing Sheets



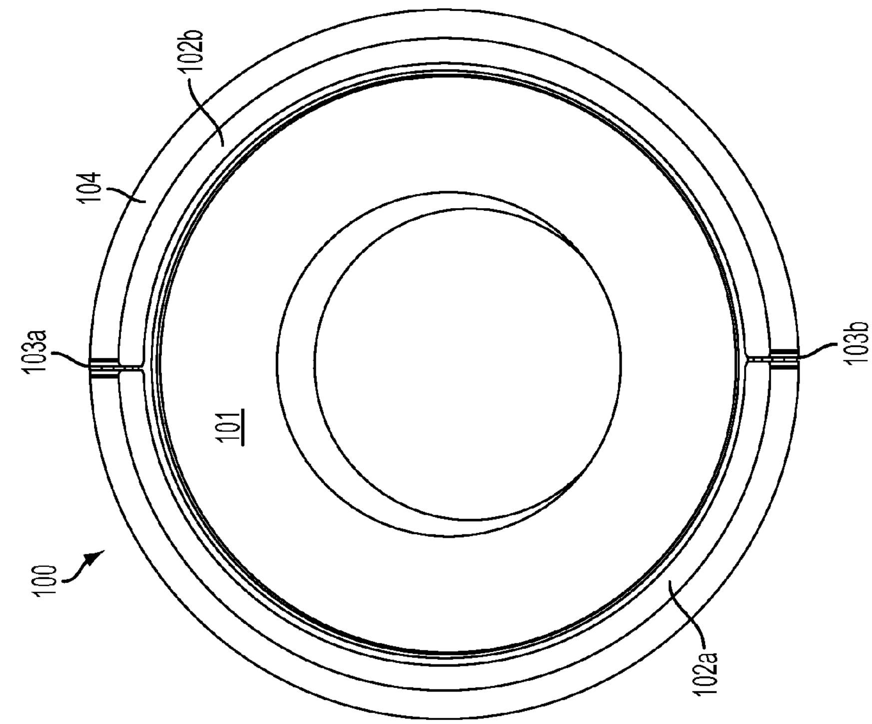


FIG. 2

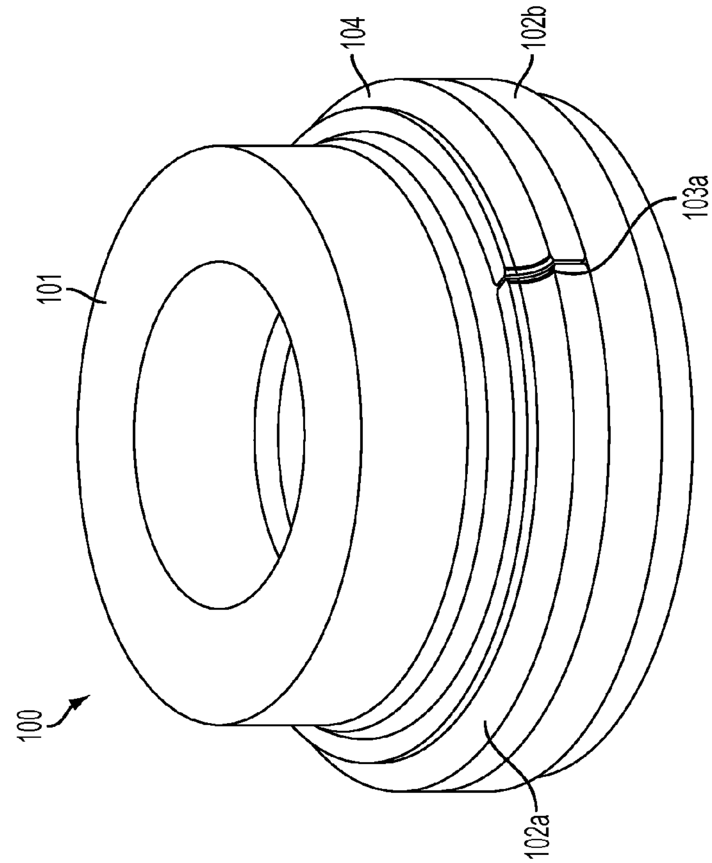


FIG. 1

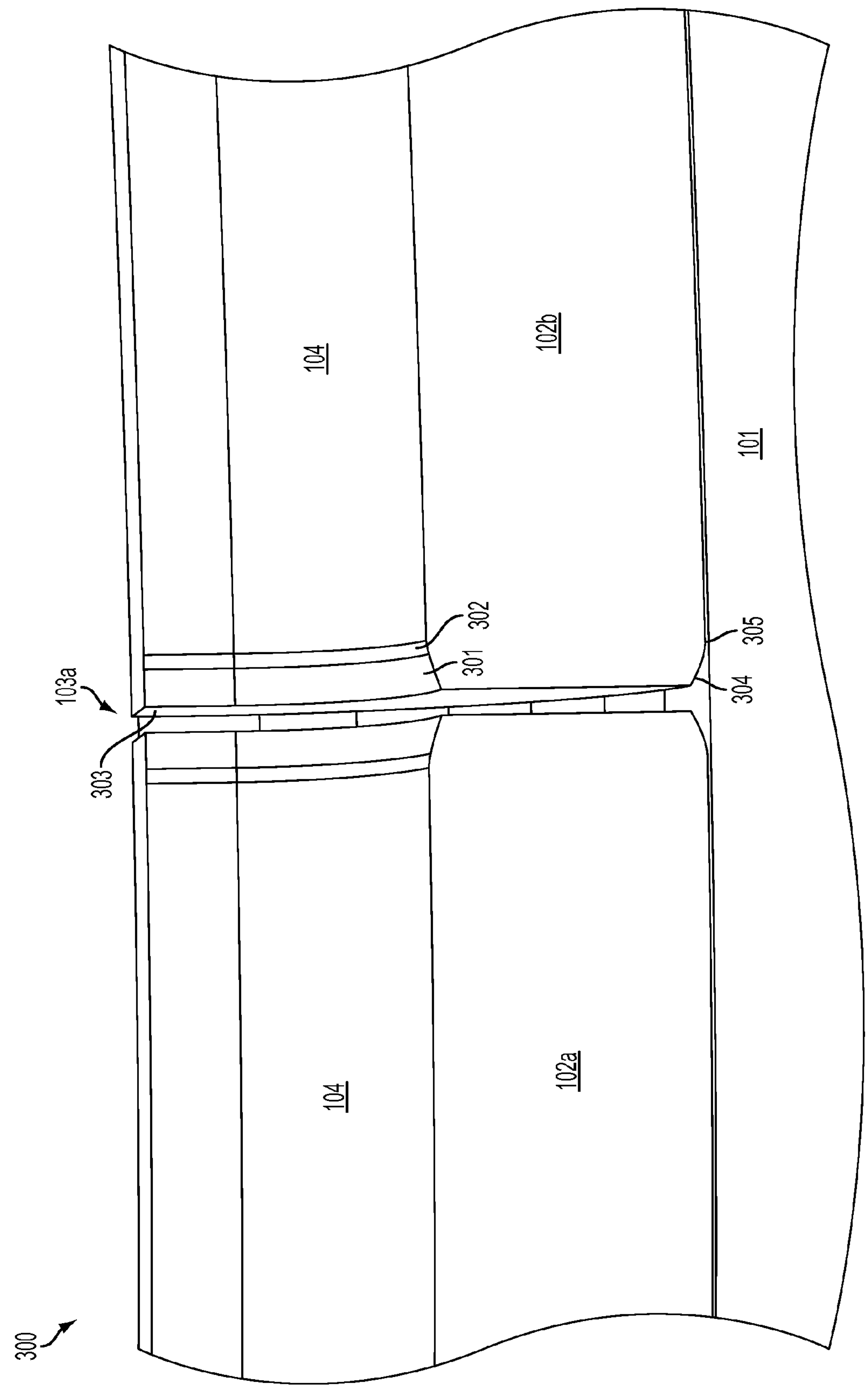


FIG. 3

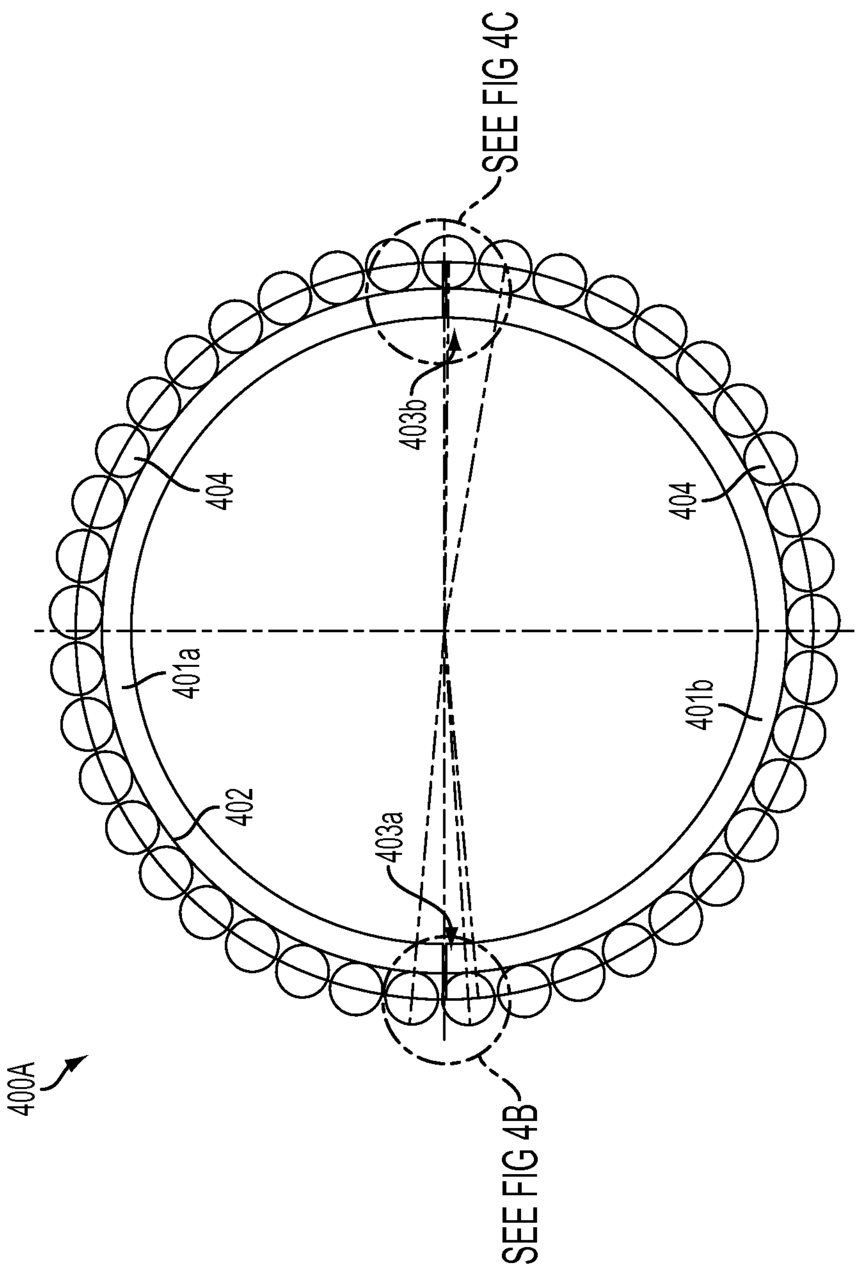


FIG. 4A

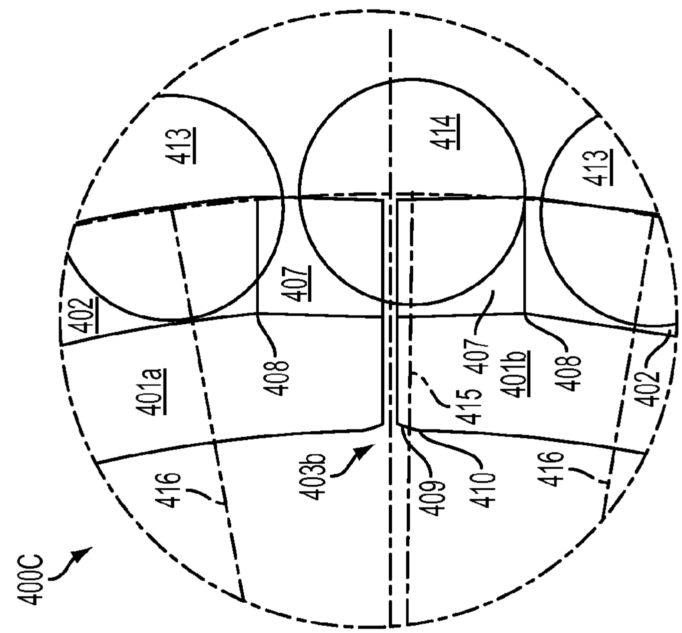

400C
413
414
413
402
407
401a
408
407
401b
408
402
415
403b
409
410
416
416

FIG. 4C

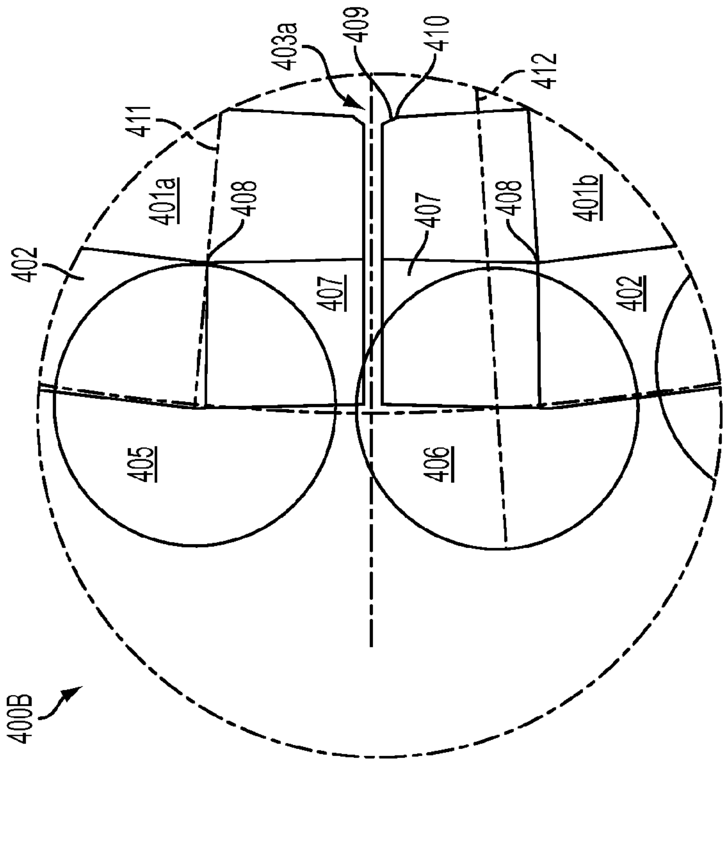

400B
403a
409
410
412
411
401a
408
408
401b
402
407
407
402
405
406

FIG. 4B

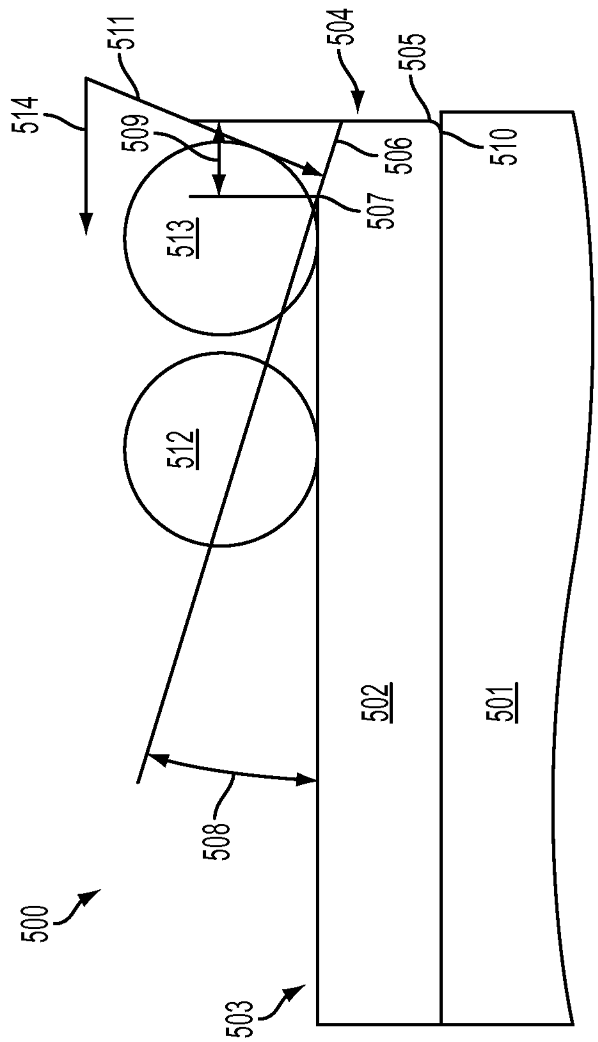


FIG. 5

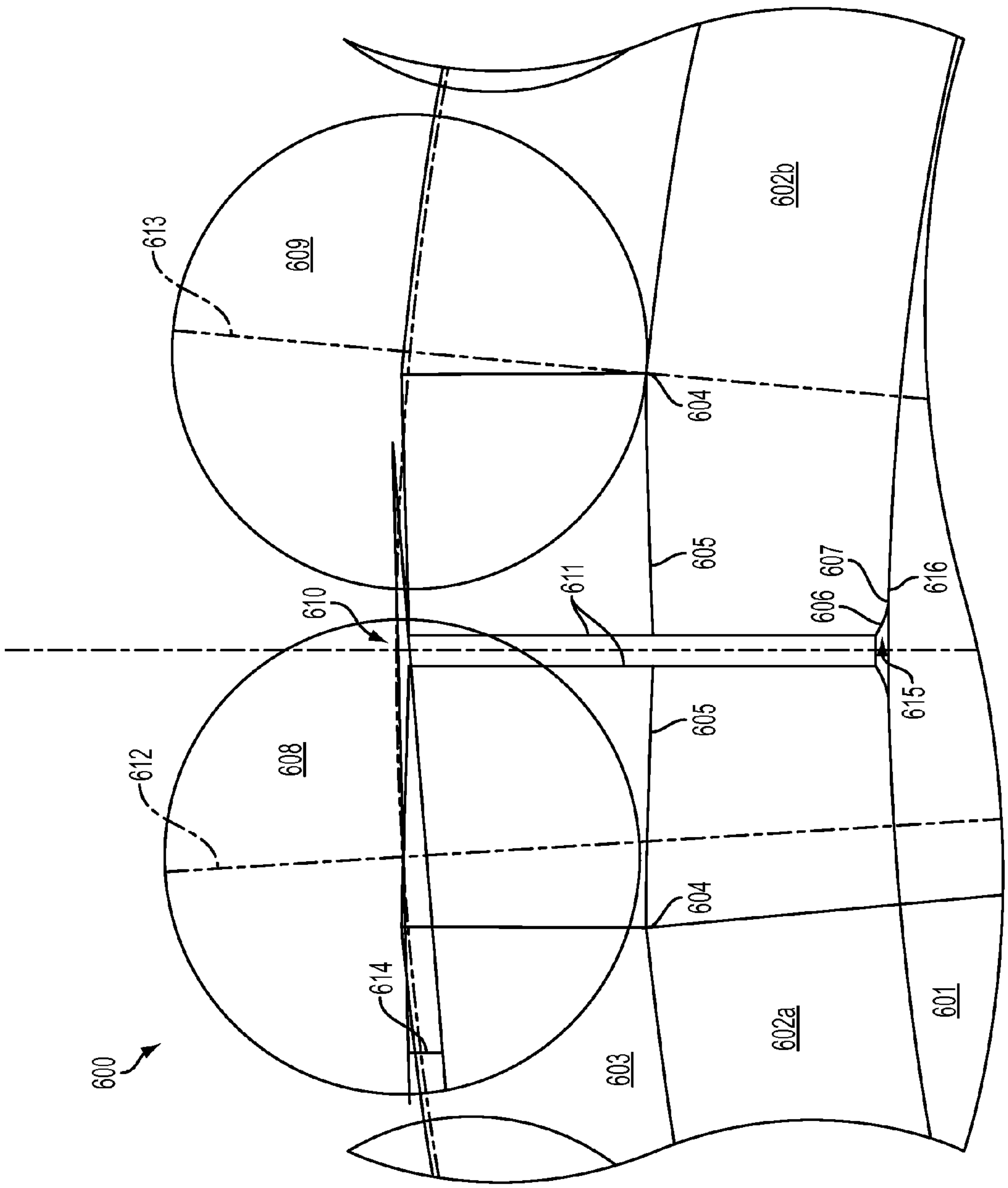

600
601
602a
602b
603
604
604
605
605
606
607
608
609
610
611
612
613
614
615
616

FIG. 6

SPLIT BLADE RETENTION RACE WITH INNER AND OUTER CHAMFERS

BACKGROUND

The subject matter disclosed herein relates generally to the field of a split blade retention race for an aircraft propeller blade.

A propeller for use in an aircraft includes a central rotating hub having a plurality of blade receiving sockets disposed about the hub. The propeller blades each have a shank, which may be a metal such as aluminum, located at the base of each propeller blade, and each shank is disposed in a respective blade receiving socket. The blade receiving sockets and the blade shanks are provided with opposed, separated ball bearing race surfaces, and a plurality of ball bearings are held between the blade receiving socket and the blade shank on the race surfaces, allowing adjustment of the pitch of the blade. The ball bearing race on the blade shank may be a separate component, referred to as a blade retention race, that encircles the blade shank. Currently, the blades are shipped with a one piece blade race.

Due to the movement and loading of the ball bearings on the race surface, and resulting damage that occurs to the race, one piece races may be replaced by split races at overhaul. Such a multisection blade retention race may be referred to as a split blade retention race. Once the one-piece race is replaced by split races, the movement and loading of the ball bearings on the edges of the split races has a tendency to damage the blade shank beyond repair.

BRIEF SUMMARY

According to one aspect, a blade shank assembly for an aircraft propeller blade includes a blade shank; and a split blade retention race encircling the blade shank, the split blade retention race comprising two sections separated by two splits, the two splits being perpendicular to a race surface of the split blade retention race, wherein the split blade retention race comprises: an inner chamfer located between a surface of the split blade retention race that is adjacent to the blade shank and a split surface of the split blade retention race at each of the two splits; and an outer chamfer located between the race surface of the split blade retention race and the split surface at each of the two splits.

According to another aspect, a split blade retention race for a blade shank assembly for an aircraft propeller blade includes a race surface; an inner surface, the inner surface being configured to be located adjacent to a blade shank in the blade shank assembly; a split surface, the split surface being perpendicular to the race surface and to the inner surface; an inner chamfer, wherein the inner chamfer is angled back from the split surface to the inner surface; and an outer chamfer, wherein the outer chamfer is angled back from the split surface to the race surface.

Other aspects, features, and techniques of the invention will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIG. **1** illustrates an embodiment of a blade shank assembly for an aircraft propeller blade including a split blade retention race.

FIG. **2** illustrates a top view of an embodiment of a split blade retention race.

FIG. **3** illustrates a detailed side view of an embodiment of a blade shank with a split blade retention race at a split.

FIG. **4**A illustrates a top view of an embodiment of a split blade retention race.

FIGS. **4**B-C illustrate detailed views of the split blade retention race of FIG. **4**A at the splits.

FIG. **5** illustrates a side view of an embodiment of a split blade retention race.

FIG. **6** illustrates a detailed view of an embodiment of a split blade retention race.

DETAILED DESCRIPTION

Embodiments of a split blade retention race with inner and outer chamfers are provided, with exemplary embodiments being discussed below in detail. The edge configuration of the inner chamfers in a split blade retention race may cause damage to the blade shank by the split blade retention race, and result in a shortened lifespan for the blade. Relatively long outer chamfers at the splits that have a relatively shallow angle with respect to the race surface may reduce such damage to the blade shank by reducing edge compressive stress to the blade shank from the split blade retention race at the inner chamfers, as well as reducing rotation of the split blade retention race on the blade shank under load. Due to the length of the outer chamfers, the split blade retention race allows a maximum of 3 balls to be unloaded simultaneously on the outer chamfers at the splits. The length of the outer chamfers ensures that a loaded ball bearing is located a defined distance from the edge of the split, such that the compressive stress by the split blade retention race on the blade shank may be near zero. A curved outer radius is also located between an outer chamfer and the race surface; a ball bearing becomes unloaded after the ball bearing passes over the curved outer radius and onto the outer chamfer.

A curved inner radius located at a defined distance from the split, between an inner chamfer and the portion of the split blade retention race that is adjacent to the blade shank, ensures that there are no sharp edges contacting the blade shank. This distance between the curved inner radius and the split ensures that the stress is near zero at the last contact location between the split blade retention race and the blade shank. For example, if the length of the inner chamfer length and radius were the same as the outer chamfer length and radius, the load from a ball bearing on an outer chamfer would transfer directly downwards through the split blade retention race to the tangent point where the edge of the inner radius on the split blade retention race touches the blade shank. However, reducing the ratio of the length of inner chamfer to the length of the outer chamfer has the effect of reducing the load to near zero at this tangent point. The outer chamfer has a length that is longer than a length of the inner chamfer. In some embodiments the length of an outer chamfer may be about 4 times the length of an inner chamfer.

FIG. **1** shows an embodiment of a blade shank assembly **100** for insertion into a blade receiving socket (not shown) of an aircraft propeller. The blade shank assembly **100** includes blade shank **101** and split blade retention race **102**_a-b_. Split **103**_a_ is located between the sections of the split blade retention race **102**_a-b_. The edges of split blade retention race **102**_a-b_ at the split **103**_a_ each include an inner chamfer on the internal side, adjacent to the blade shank **101**, and an outer chamfer on the external side, adjacent to the race surface **104** of the split blade retention race **102***a-b*. Ball bearings (shown below with respect to FIGS. **4**A-**6**) are located on the race surface **104**.

FIG. **2** shows a top view of the blade shank assembly **100**, including blade shank **101** and split blade retention race **102***a-b*. Ball bearings move on the race surface **104** of split blade retention race **102***a-b*, and pass over splits **103***a-b*. Splits **103***a-b* are located between the sections of the split blade retention race **102***a-b*, and are perpendicular to the race surface **104**. A ball bearing that is located on an outer chamfer within a calculated distance of a split **103***a-b* is unloaded. The configuration of the splits **103***a-b* in split blade retention race **102***a-b* is such that a maximum of three ball bearings are unloaded simultaneously. The remaining the ball bearings are located on the race surface **104** and share the load.

FIG. **3** shows a side view **300** of a blade shank **101** and a split blade retention race **102***a-b* at a split **103***a*. Race surface **104** is the surface on which the ball bearings are held. The edge geometry of split blade retention race **102***b* at split **103***a* includes an outer chamfer **301**, outer radius **302**, split surface **303**, inner chamfer **304**, and inner radius **305**; the edge geometry of edge geometry of split blade retention race **102***a* corresponds to that of split blade retention race **102***b*. Outer chamfer **301** comprises a straight surface that is angled back from split surface **303** towards race surface **104**, such that there is a dip in the race surface **104** adjacent to the split **103***a*. Outer chamfer **301** has a relatively shallow angle with respect to race surface **104**, about 5 degrees in some embodiments. A curved outer radius **302** joins with outer chamfer **301** to race surface **104**. Split surface **303** of section **102***b* of the split blade retention race **102***a-b* is located inside of split **103***a*, and directly faces and is parallel to a corresponding split surface on the other section **102***a* of the split blade retention race **102***a-b* on the other side of the split **103***a*. Inner chamfer **304** comprises a straight surface that is angled back from split surface **303** to an inner surface of the split blade retention race that is adjacent to the blade shank **101**. A curved inner radius **305** joins the inner chamfer **304** to the surface of the split blade retention race **102***a-b* that is adjacent to blade shank **101**.

FIG. **4**A shows a top view **400**A of a split blade retention race **401***a-b* with splits **403***a-b*. Ball bearings, such as ball bearings **404**, are located on the race surface **402** of the split blade retention race **401***a-b*. Due to the configuration of splits **403***a-b*, up to a maximum of 3 ball bearings may be unloaded on splits **403***a-b* simultaneously. In the embodiment of FIG. **4**A, assuming that the ball bearings are moving counter-clockwise on the race surface **402**, one ball bearing is unloaded at split **403***a*, one ball bearing is on the verge of becoming unloaded at split **403***a*, and one ball bearing is unloaded at split **403***b*. A detailed view **400**B of split **403***a* is shown in FIG. **4**B, and a detailed view of split **403***b* is shown in FIG. **4**C. In detailed view **400**B of FIG. **4**B, the outer chamfers **407** have a relatively long, shallow angle with respect to race surface **402**. Center load line **411** shows the load path of ball bearing **405** on the outer radius **408**, and center load line **412** shows the load path of ball bearing **406** on the outer chamfer **407**. Inner radii **410** and inner chamfers **409** are located at the bottom of the split **403***a*. As shown in FIG. **4**B, ball bearing **405** is located on an outer radius **408**, such that ball bearing **405** is currently loaded, but is on the verge of becoming unloaded on the outer chamfer **407**. A ball bearing is not unloaded when it is located on outer radius **408**, due to the compressive deflection of the ball on the race surface **402**. Ball bearing **406** is located on the surface of an outer chamfer **407**, and is unloaded. As ball bearings **405** and **406** move downward, ball bearing **405** becomes unloaded as it moves from outer radius **408** to outer chamfer **407**, and the ball bearings **405** and **406** are then both unloaded until ball bearing **406** reaches outer radius **408**. In detailed view **400**C of FIG. **4**C, ball bearing **414** is located on an outer chamfer **407** and is unloaded, as indicated by center load line **415**, while ball bearings **413** are located on the race surface **402** and are loaded on the race surface **402**, as indicated by center load lines **416**. Inner radii **410** and inner chamfers **409** are located at the bottom of the split **403***b*. The outer radii **408** may have a curvature that is about twice a curvature of the inner radii **410** in some embodiments.

FIG. **5** illustrates a side view **500** of an embodiment of a split blade retention race **502** on a blade shank **501**. Ball bearings **512** and **513** are located on race surface **503** of split blade retention race **502**, and are loaded. Outer radius **507** and outer chamfer **506** are located between race surface **503** and split surface **504**. Inner chamfer **505** and inner radius **510** are located between split surface **504** and the portion of split blade retention race **502** that is adjacent to blade shank **501**. Angle **508** shows the angle of outer chamfer **506** with respect to the race surface **503**, which is relatively small (about 5 degrees in some embodiments), and distance **509** shows the length of outer chamfer **506**, which may be relatively long, due to the shallow angle **508**, so as to reduce stress at the point where the inner radius **510** of split blade retention race **502** comes into contact with the blade shank **501**. When a loaded ball bearing is located on a portion of the outer chamfer **506**, load line **511** indicates the direction of the normal load from that ball bearing onto the outer chamfer **506**, and load component **514** indicates the rotational load, which causes rotation of the split blade retention race **502** on the blade shank **501** and therefore should be reduced. The relatively shallow angle **508** of the outer chamfer **506** reduces the rotation of the split blade retention race **502** due to the rotational load indicated by load component **514**, thus reducing wear from the split blade retention race **502** on the blade shank **501**. The outer radii **507** may have a curvature that is about twice a curvature of the inner radii **510** in some embodiments. The outer chamfer **506** has a length that is longer than a length of the inner chamfer **505**; the outer chamfer **506** may have a length that is about 4 times a length of the inner chamfer **505** in some embodiments.

FIG. **6** illustrates a detailed view **600** of an embodiment of a split blade retention race. Split blade retention race **602***a-b* is located on blade shank **601**, and includes race surface **603**. Split **610** is perpendicular to race surface **603**. At split **610**, both sections of split blade retention race **602***a-b* include outer radii **604**, outer chamfers **605**, split surfaces **611**, inner chamfers **606**, and inner radii **607**. In FIG. **6**, ball bearing **608** is located on outer chamfer **605** and is unloaded, as indicated by center load line **612**. Ball bearing **609** is located on outer radius **604** and is on the verge of becoming unloaded on the outer chamfer **605**, depending on the compressive deflection of the race surface **603** under load. As the ball bearing **608** and **609** move to the left, both of ball bearings **608** and **609** will be unloaded on split **610**. Angle **614** shows the angle of outer chamfer **605** with respect to the race surface **603**, and is relatively shallow (in some embodiments, about 5 degrees). The length of an outer chamfer **605** (as is illustrated by distance **509** of FIG. **5**) is longer than the length **615** of the inner chamfer **606**; the outer chamfer **605** may be 4 times longer than the inner chamfer **606** in some embodiments. Inner radius **607** joins the inner chamfer **606** to the surface of the split blade retention race **602***a-b* that is adjacent to blade shank **601**, and is tangent to the blade shank **601** at point **616**. The load at point **616** from the split blade retention race **602***b* on the blade shank **601** is near zero, and no sharp edge contacts the blade shank **601** at point **616**. The outer radii **604** may have a curvature that is about twice a curvature of the inner radii **607** in some embodiments.

The technical effects and benefits of exemplary embodiments include reduction of blade shank damage due to blade race split configuration as well as reduction in wear in the split race edges.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. While the description of the present invention has been presented for purposes of illustration and description, it is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications, variations, alterations, substitutions, or equivalent arrangement not hereto described will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. Additionally, while various embodiment of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

The invention claimed is:

1. A blade shank assembly for an aircraft propeller blade, comprising:
- a blade shank; and
- a split blade retention race encircling the blade shank, the split blade retention race comprising two sections separated by two splits, the two splits being perpendicular to a race surface of the split blade retention race, wherein the split blade retention race comprises:
  - an inner chamfer located between a surface of the split blade retention race that is adjacent to the blade shank and a split surface of the split blade retention race at each of the two splits; and
  - an outer chamfer located between the race surface of the split blade retention race and the split surface at each of the two splits.

2. The blade shank assembly of claim **1**, further comprising a plurality of ball bearings located on the race surface of the split blade retention race.

3. The blade shank assembly of claim **1**, wherein the split surface comprises a surface that is located on the split blade retention race inside of a split, such that a first split surface of a first section is directly opposite and parallel to a corresponding second split surface of a second section across the split.

4. The blade shank assembly of claim **1**, wherein the inner chamfer comprises a straight surface that is angled back from the surface of the split blade retention race that is adjacent to the blade shank to the split surface of the split blade retention race.

5. The blade shank assembly of claim **4**, further comprising an inner radius comprising a curved surface that is located between the inner chamfer and the surface of the split blade retention race that is adjacent to the blade shank.

6. The blade shank assembly of claim **1**, wherein the outer chamfer comprises a straight surface that is angled back from the race surface of the split blade retention race to the split surface.

7. The blade shank assembly of claim **6**, further comprising an outer radius comprising a curved surface that is located between the outer chamfer and the race surface of the split blade retention race.

8. The blade shank assembly of claim **7**, wherein a ball bearing of a plurality of ball bearings on the race surface is loaded based on a center load line of the ball bearing being located on the race surface, and fully unloaded based on a center load line of the ball bearing being located on one of an outer chamfer and a split.

9. The blade shank assembly of claim **8**, wherein up to a maximum of three ball bearing of the plurality of ball bearings are unloaded simultaneously.

10. The blade shank assembly of claim **9**, wherein one of the three unloaded ball bearings is located at a first split of the two splits, and two of the three unloaded ball bearings are located at a second split of the two splits.

11. The blade shank assembly of claim **1**, wherein the outer chamfer has an angle of about 5 degrees with respect to the race surface.

12. The blade shank assembly of claim **1**, wherein a length of the outer chamfer is longer than a length of the inner chamfer.

13. The blade shank assembly of claim **12**, wherein the length of the outer chamfer is about 4 times the length of the inner chamfer.

14. A split blade retention race for a blade shank assembly for an aircraft propeller blade, comprising:
- a race surface;
- an inner surface, the inner surface being configured to be located adjacent to a blade shank in the blade shank assembly;
- a split surface, the split surface being perpendicular to the race surface and to the inner surface;
- an inner chamfer, wherein the inner chamfer is angled back from the split surface to the inner surface; and
- an outer chamfer, wherein the outer chamfer is angled back from the split surface to the race surface.

15. The split blade retention race of claim **14**, wherein the race surface is configured to hold a plurality of ball bearings.

16. The split blade retention race of claim **14**, wherein the inner chamfer comprises a straight surface, and further comprising an inner radius comprising a curved surface that is located between the inner chamfer and the inner surface; and
- wherein the outer chamfer comprises a straight surface, and further comprising an outer radius comprising a curved surface that is located between the outer chamfer and the race surface.

17. The split blade retention race of claim **14**, wherein a curvature of the outer chamfer is about twice a curvature of the inner chamfer.

18. The split blade retention race of claim **14**, wherein a length of the outer chamfer is longer than a length of the inner chamfer.

19. The split blade retention race of claim **18**, wherein the length of the outer chamfer is about 4 times the length of the inner chamfer.

20. The blade shank assembly of claim **14**, wherein the outer chamfer has an angle of about 5 degrees with respect to the race surface.

* * * * *